

GOLF STROKE TRAINING DEVICE

Background of the Invention

5 The present invention relates to a golf stroke training device for assisting an individual in practicing a golf stroke. In particular, the invention relates to a device for assisting a golfer in practicing a putting stroke.

10 An important aspect of a golfer's game is the ability to putt a golf ball accurately into the cup of a hole on a golf course. Although simple in concept, it is actually difficult to master and maintain a proper putting technique. There are a variety of errors that can occur from the time a golfer addresses the ball on a 15 green right through to the point at which the golfer makes contact with the ball. Correcting any such errors requires a golfer to practise repeatedly his or her stroke in order to develop a feel for a proper, effective stroke. It is therefore desirable to have a practice aid 20 that enables a golfer repeatedly to practise their putting stroke, whilst providing a degree of feedback to the golfer which will allow them to develop a feel for the stroke which can be quickly and successfully transferred to their actual game. Furthermore, as 25 conditions on different putting greens vary, i.e. the greens may be of different "speeds" or have varying contours or undulations, it is also desirable to have a practice aid which can simulate conditions on a variety of putting greens.

30 WO-A-00/09216 and corresponding U.S. Patent No. 6,146,283 disclose a golf putting training device, developed to aid a golfer in practicing their putting stroke. The device includes a user interface for allowing a user to pre-select a putting green speed, or "stimp 35 value", before making a practice putt. The device also

includes a target mounted at an end of a shaft, which target rotates in a vertical plane about a central fixing of the shaft when struck by a user. Using the pre-selected stimp value, and the initial angular 5 velocity of the target, which is calculated by a putting force sensor, a microprocessor of the device is able to determine the notional distance of the putt made by a user. A problem of using this device is that the 10 resistance to the motion of the ball is always the same from the moment the ball is struck. Thus, the device does not allow a golfer to develop a feel for putting a golf ball on surfaces of varying frictional resistances.

GB-B-2316010 and corresponding U.S. Patent No. 5,997,405 disclose a golf training device, developed to 15 aid a golfer in practicing iron shots. The device includes a golf ball which is tethered by a flexible cord to a wheel which is mounted for rotation in a horizontal plane. A user makes a pre-shot club selection in order to communicate to the device which club he is using. The 20 ball is then placed on the ground, or on a golf tee, before the user plays his stroke. The wheel to which the ball is tethered carries on its upper surface an optical ring having a number of equally-spaced fingers which project from its upper surface. A photo-emitter and 25 opposing photo-receiver are arranged on opposite sides of the ring so when the ball is struck, and the wheel and ring arrangement thereby caused to rotate, the fingers of the ring intermittently interrupt a beam of light emitted by the photo-emitter, so that the photo-detector detects 30 a series of pulses of light, each pulse comprising light from the photo-emitter which has penetrated a gap provided between adjacent fingers of the wheel. By counting the number of light pulses detected in a

predetermined period of time, the device is able to calculate the initial velocity of the target, and by comparing this with pre-programmed data for the specific club used, is able to derive a notional distance which 5 the ball would have traveled if it had not been tethered. The notional distance is communicated to the user by a display unit which is mounted on the device. A disadvantage of this device is that it cannot be used for practicing putting strokes because the ball's movement 10 along the floor would be impaired by the flexible cord which attaches it to the device. Furthermore, the device cannot provide a visual, real-time indication of how far the ball would have traveled had it been free, rather than tethered.

15 It is an object of the invention to provide an improved training device to assist a golfer in improving their putting technique.

It is a further object of the invention to provide a training device that accurately simulates the feel of 20 putting on surfaces of different frictional resistances, and which is able to provide a visual, real-time indication of the distance that a free ball would have traveled on a putting green.

Summary of the Invention

25 The above and other objects and advantages of the invention are achieved according to one aspect of the invention by the provision of a golf stroke practicing aid comprising a target adapted to be struck by a golf- club, guiding means for constraining the target to move 30 in a substantially horizontal orbit when struck, and measuring means for measuring the initial speed of the target when struck. Processing means are provided which are configured to determine a notional total distance

that the target should travel in its orbit corresponding to the initial speed, and motion controlling means serve to control the movement of the target in its orbit when struck such that the target actually moves a total
5 distance which is substantially the same as the notional total distance.

An advantage of such a device is that it allows a user to observe the motion of the target after it has been struck, and to develop an awareness of exactly how
10 far the ball has traveled.

The notional total distance may be the total distance that a standard golf ball would have traveled freely on a real putting green.

In some embodiments, the processing means are
15 adapted to calculate a notional relationship between the instantaneous speed of the target and the elapsed time after striking said target based on said notional total distance, said measuring means are adapted to measure continually the elapsed time after striking the target
20 and the actual instantaneous speed of the target as it moves in said orbit, and said motion controlling means are adapted to compare the actual instantaneous speed with said notional instantaneous speed and to adjust continually the speed of the target accordingly to ensure
25 that the target moves about said total distance.

The measuring means may comprise a first motion detector which is adapted to generate a first pulsed motion detection signal in response to movement of the target, the frequency of said first pulsed signal corresponding to the speed of the target.
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Typically each pulse corresponds to movement of the target in said orbit by a predetermined increment of distance, said measuring means being adapted to calculate

the speed of the target from time between successive pulses.

In some embodiments, the motion detector comprises a first rotatable part and a first fixed part, the first 5 rotatable part being coupled to the target such that movement of the target in its orbit when struck causes corresponding rotation of said first rotatable part about an axis of rotation relative to the first fixed part, wherein one of said first rotatable and fixed parts 10 comprises a first optical encoder ring which is disposed substantially co-axially with the axis of rotation, and the other of said parts comprises a first photo-emitter and a first photo-detector adapted to detect light emitted by said first photo-emitter, wherein said first 15 optical encoder ring comprises a plurality of regular formations which are circumferentially spaced at substantially equal intervals about said encoder ring to define a plurality of regular gaps therebetween, said first photo-emitter is arranged to direct a beam of light 20 at the first encoder ring, such that the formations intermittently interrupt the beam as the first rotatable part rotates to produce a series of pulses of light; and said first photo-detector is arranged to detect said 25 pulses of light and to generate a corresponding first pulsed motion detection signal in which each pulse corresponds to a pulse of light.

In some embodiments the practicing aid may further comprise direction determining means for determining the direction of movement of the target in its orbit.

30 Preferably the direction determining means comprise a second motion detector which is adapted to generate a second pulsed motion detection signal in response to movement of the target, the frequency of said second

pulsed signal corresponding to the speed of the target and being substantially the same as the frequency of the first pulsed signal, and comparing means for comparing the first and signal signals, the phases of the first and 5 second pulsed signals being off-set to allow said comparing means to determine, and said comparing means being configured to determine, the direction of movement of the target by quadrature.

The practicing aid may further comprise a second motion detector comprising a second rotatable part and a second fixed part, the second rotatable part being coupled to the target such that movement of the target in its orbit when struck causes corresponding rotation of said second rotatable part about an axis of rotation 10 relative to the second fixed part, wherein one of said second rotatable and fixed parts comprises a second optical encoder ring which is disposed substantially coaxially with the axis of rotation, and the other of said parts comprises a second photo-emitter and a second photo-detector adapted to detect light emitted by said second photo-emitter, wherein said second optical encoder ring comprises a plurality of regular formations which are circumferentially spaced at substantially equal 15 intervals about said encoder ring to define a plurality of regular gaps therebetween, said second photo-emitter is arranged to direct a beam of light at the second encoder ring, such that the formations intermittently interrupt the beam as the second rotatable part rotates to produce a series of pulses of light; and said second photo-detector is arranged to detect said pulses of light 20 and to generate a corresponding second pulsed motion detection signal in which each pulse corresponds to a pulse of light, the first and second motion detectors 25

being configured and arranged such the frequencies of said first and second pulsed signals are substantially the same, and the phases of the first and second pulsed signals are off-set such that the direction of movement 5 of the target can be determined by quadrature.

Typically the phases of said first and second pulsed signals are offset by about 90°.

The motion controlling means may comprise: a motor which is drivingly coupled to said target for controlling 10 movement thereof; and motor controlling means for controlling operation of the motor.

Preferably, the motor controlling means comprise an H-bridge motor drive.

In some embodiments the practicing aid may further 15 comprise restoring means for restoring the target to a home position.

One of said first and second optical encoder rings may comprise a home formation having a unique size or spacing as compared with the other formations on said one 20 ring for allowing the rotational orientation of the respective rotatable part, and thus the rotational orientation of the target, to be determined.

The home formation may be configured so as to alter transiently the phase off-set between said first and 25 second motion detection signals when the target is at its home position.

The respective rotatable part may be arranged such that said home formation is disposed adjacent the respective photo-emitter and photo-detector when the 30 target is in the home position.

The practicing aid may further comprise home restoring means which are adapted to generate a home restoration signal for controlling said motion

controlling means to move the target at a constant speed in its orbit, and to analyze the pulsed motion detection signals generated by the respective motion detectors for determining when the home finger is disposed adjacent the 5 respective photo-emitter and photo-detector, said home restoring means being configured to control the motion controlling means then to halt so that the target is positioned at the home position.

Typically a reset button is provided on the device 10 which can be pushed by the user, preferably with the heel of his putter, so that the target can be returned to the home position before the user strikes the ball again and without the user having to make much adjustment to his positioning. This means that the user can remain 15 substantially in the same position and repeat a particular putt several times until he is satisfied with his performance, aiding development of his muscle memory and increasing the likelihood that the user will be able to perform the putt well again, whether practicing on the 20 device or whether putting on a putting green.

The guiding means comprise a or substantially rigid arm, said target being mounted on one end of the arm and the other end of the arm being secured to one of said first and second rotatable parts.

25 Preferably the target comprises a standard golf ball, although it will be appreciated that any equivalent target having substantially the same dimensions and weight as a golf ball may be employed.

The device may further comprise display means for 30 receiving and displaying information to a user. For example, the display means may be used to display to a user the numerical distance that the target has moved following a strike.

In some embodiments, the device may comprise communication means for transmitting data to and/or receiving data from external equipment. The external source may comprise a monitor, games console, personal 5 computer, or an information store which contains operation parameters that can be accessed and processed by the device.

The device may further comprise user input means for manually selecting of one or more parameters of operation 10 of the practicing aid. For example, the user input means may be used to select a desired stimp value. The user input means may comprise, for example, one or more buttons, switches, dials or the like.

In accordance with another aspect of the invention 15 there is provided a golf stroke training device comprising: a supporting structure which is adapted to stand stably on the ground in use; a rotator defining an axis of rotation, said rotator being rotatably mounted to said supporting structure such that said axis of rotation 20 extends substantially vertically when the supporting structure stands on the ground, said rotator being adapted for rotation about said axis; a rigid or substantially rigid arm having an inner end and an outer end, said inner end being connected to said rotator, said 25 arm being arranged such that said outer end is adapted to rotate in a substantially horizontal plane upon rotation of the rotator; a target adapted to be struck by a golf-club, said target being joined to said outer end of said arm, such that when the target is struck by a golf-club, 30 the target is caused to rotate about said axis of rotation in a substantially horizontal orbit; a first optical encoder ring mounted on said rotator for rotation therewith, said first optical encoder ring comprising a

plurality of regular formations which are circumferentially spaced about said axis of rotation at substantially equal intervals, said ring having a first inner side and a second outer side; a first photo-emitter 5 adapted to emit a beam of light, and a first photo-detector adapted to detect light emitted by said first photo-emitter, said first photo-emitter and first photo-detector being fixedly mounted to said supporting structure on opposite sides of said first optical encoder 10 ring, such that said beam is directed across the formations of the first optical encoder ring towards said first photo-detector, such that said formations interrupt the beam intermittently as the rotator rotates to produce a series of pulses of light, which pulses of light are 15 detected by said photo-detector to produce a first pulsed motion detection signal, whereby the time between successive pulses of said pulsed motion detection signal is proportional to the speed of said target; a motor which is mounted to said supporting structure and 20 drivably coupled to the rotator for adjusting the speed of the rotator; a motor controller for controlling the motor; and a microcontroller having an input which is adapted to receive said first motion detection signal, a clock configured to provide a constant measure of time, a 25 microprocessor adapted continually to process said first motion detection signal to determine the actual instantaneous speed of the target, said microprocessor being programmed to detect when the target is struck and to calculate the initial speed of said target, a memory device storing distance information relating a total 30 notional distance to be traveled by the target to said initial speed, said microprocessor being programmed for determining from said initial speed and said distance

information a particular notional total distance to be traveled by said target and for determining from said particular total notional distance a relationship between the notional instantaneous speed of the target and the 5 time elapsed since the target was struck, said microprocessor being further programmed to compare continually the actual instantaneous speed of the target with said notional instantaneous speed to generate a velocity error value, and to generate a motor control 10 signal corresponding to said velocity error value, and an output adapted for outputting said motor control signal to said motor controller for controlling the motor to adjust the actual instantaneous speed of the target to said notional instantaneous speed, such that the actual 15 total distance traveled by said target in its orbit is substantially the same as said particular notional total distance.

The memory device may store a plurality of different, predetermined, user-selectable values of 20 notional resistance to rotation of the rotator, and stores distance information for each value of notional resistance relating the total notional distance to be traveled by the target to said initial speed, said microcontroller further comprises a user-selection input 25 component which is adapted to enable a user to select a desired one of said predetermined values.

The training device may further comprise a second optical encoder ring mounted to the rotator for rotation therewith, said second optical encoder ring being 30 arranged substantially coaxially with said first optical encoder ring, and comprising a plurality of regular formations which are circumferentially spaced about said axis of rotation at substantially equal intervals, said

ring having a first inner side and a second outer side; a second photo-emitter adapted to emit a beam of light, and a second photo-detector adapted to detect light emitted by said second photo-emitter, said second photo-emitter and second photo-detector being fixedly mounted to said supporting structure on opposite sides of said second optical encoder ring, such that said beam is directed across the formations of said second optical encoder ring, such that said formations can interrupt said beam intermittently as the rotator rotates to produce a series of pulses of light, which pulses of light are detected by said photo-detector to produce a second pulsed motion detection signal; said first and second optical encoder rings, said first and second photo-emitters and said first and second photo-detectors being configured and arranged such the frequencies of said first and second pulsed signals are substantially the same, and the phases of the first and second pulsed signals are off-set; wherein said input is further adapted to receive said second motion detection signal, and said microprocessor is further programmed to compare said second motion detection signal with said first motion detection signal to determine the direction of rotation of the rotator by quadrature.

The motor controller may comprise an H-bridge motor drive.

In some embodiments, one of said first and second optical encoder rings comprises a home formation of unique size or unique spacing as compared with the other formations on said one optical encoder ring, said home formation being positioned on said one encoder ring such that said home formation is positioned adjacent the respective photo-emitter and photo-detector when the

target is in a home position; and said microprocessor is programmed with a selectively operable home restoration routine, which home restoration routine comprises outputting appropriate motor control signals for 5 controlling said motor to drive said rotator at a constant angular velocity whilst processing the respective motion detection signal to detect the home formation, and when said home formation is detected ceasing output of said motor control signals to halt 10 operation of the motor, thereby bringing said rotator to rest at the home position.

In accordance with another aspect of the invention there is provided a putting practicing aid comprising: a base member that is adapted to stand stably on the 15 ground; a rotator mounted to the base member and adapted for rotation about a substantially vertical axis; a target mounted to said rotator for rotation about said axis in a substantially horizontal orbit, said target being adapted to be struck by a golf putter; and motion 20 controlling means for controlling rotation of said rotator by applying a predetermined resistance to movement of the target to simulate the feel of putting a golf ball on a real green.

The motion controlling means may be configured to 25 apply selectively a plurality of different, predetermined, user-selectable values of resistance to rotation of the rotator, and means are provided to enable a user to select a desired one of said predetermined values.

30 Preferably said motion controlling means comprise a motor drivably connected to said rotator.

The motion controlling means may comprise means for measuring the initial velocity of the rotator, clock

means for measuring the time elapsed from striking the target, means for calculating a notional total distance to be traveled from said initial velocity and said value of resistance to rotation, means for calculating a notional relationship between notional instantaneous speed of said rotator and elapsed time after striking from said notional total distance to be traveled, means for continually measuring the actual instantaneous speed of the rotator at predetermined elapsed times after the target is struck, speed comparing means for comparing the actual instantaneous speed of the rotator at each elapsed time with the notional instantaneous speed, and means for adjusting the speed of the rotator as necessary to the notional instantaneous speed.

Said base member typically comprises a base plate, the plane of which is intended to be oriented horizontally during use of the device, and arranged such that the plane of movement of the target lies substantially parallel to and in close proximity to the uppermost surface of the plate, but which does not touch the plate. Preferably distance indicators are marked on the base plate, so that a user can clearly see how far the target has moved. One or more spirit levels positioned on the top of the device and adjustable feet on the lowermost side of the base plate may be provided for ensuring the device is horizontal before a shot is played.

The device may also include a metronome for allowing a user to practice the timing of their stroke. Preferably the metronome can be switched on or off independently of the main device, so that it can be used as and when it is required.

In accordance with a different aspect of the invention there is provided a putting practicing aid comprising: a base member adapted to stand stably on the ground, said base member having an upper surface; a 5 rotator mounted to the base member for rotation about a substantially vertical axis; a target mounted to said rotator for rotation about said axis in a substantially horizontal orbit, said target being adapted to be struck by a golf putter; and an elongate golf putter guiding 10 member, said guiding member being detachably mountable to the upper surface of said base member, and having a guiding surface, said guiding surface being configured and arranged such that when a user of the practicing aids strikes the target, the heel of the user's putter moves 15 along the length of said guiding surface, in contact or in close proximity therewith, so as to guide the putter along the length of said guiding surface during a stroke.

As the golf putter guiding member is detachably mountable to the support, the guiding member needs only 20 to be attached to the support when its use is required. When use of the guiding member is not required, the guiding member can simply be removed from the support.

The guiding surface may be straight, or may curve convexly along its length, i.e. orthogonal to the 25 vertical direction. A straight guide surface is generally used for practicing putts of a short distance, whilst a curved guide surface is preferred for practicing putts which are relatively long in distance. As a general rule, longer putts require a golfer to adopt a greater back-swing and follow-through than would be adopted for a 30 relatively short putt. A slight curve along the length of the guide surface (i.e. a curve which, when the golf putter guiding member is installed on the practicing aid,

extends horizontally) helps to guide a user's putter throughout the duration of his stroke.

Preferably the guiding surface is arranged substantially vertically in use.

5 Preferably the curve of the guiding surface defines an arc of an ellipse.

Preferably the golf putter guiding member has two opposite vertical putter guiding surfaces, and said guiding member is adapted to be mounted on the base 10 member in two different configurations, such that in each configuration, a different respective one of the putter guide surfaces faces the target and can be used for guiding the putter of a user.

Preferably when the putter guiding member has two 15 opposite putter guide surfaces, one of said guide surfaces is straight and the other guide surface curves along its length. Advantageously, this allows a user to switch between a "straight guide" and a "curved guide" as desired, by simply detaching the guiding member from the 20 support, rotating the guide through 180° and then remounting the guiding member to the support in the other of its two configurations.

Preferably the golf putter guiding member has a lower portion, and is mountable to said support via two 25 or more spaced protrusions which are provided on said lower portion, said protrusions being adapted to be inserted into two or more sockets provided in the upper surface of the base member, said sockets being arranged in positions which correspond to the arrangement of said 30 protrusions.

It will be appreciated that the protrusions on the lower portion of the guiding member can be provided in any suitable arrangement. Typically, the protrusions are

spaced so as to provide a secure fit between the guiding member and the base member. In order to allow the guiding member to be effectively mounted in both of its opposite configurations using the same protrusions and sockets, 5 the protrusions, and therefore the corresponding sockets, may be substantially symmetrically arranged about a central axis of the guiding member.

In accordance with yet another aspect of the present invention, there is provided a golf stroke practicing aid 10 comprising: a target adapted to be struck by a golf-club from a home position; guiding means for constraining said target to move in a substantially horizontal orbit when struck; and home restoring means for restoring the target to the home position after the target has been moved from 15 said home position, said restoring means comprising a detector for detecting when the target is at the home position, a motor which is drivingly coupled to said target, and motor controlling means for controlling operation of the motor which motor controlling means 20 causes the motor to drive said target until the detector detects that the target is at the home position whereupon the motor controlling means causes the motor and target to halt.

Preferably said detector comprises a rotatable part 25 and a fixed part, the rotatable part being coupled to the target such that movement of the target in its orbit when struck causes corresponding rotation of the rotatable part about an axis of rotation relative to the fixed part, wherein one of said rotatable and fixed parts 30 comprises an optical encoder ring which is disposed substantially co-axially with the axis of rotation, and the other of said parts comprises a photo-emitter and a photo-detector adapted to detect light emitted by said

photo-emitter, wherein said encoder ring comprises a home formation which either interrupts said beam or allows passage of said beam, as the rotatable part rotates, to allow orientation of the target to be determined.

5 Preferably said home formation is disposed adjacent the photo-emitter and photo-detector when the target is at the home position.

10 In yet another aspect of the present invention, there is provided a putting practicing aid comprising: a base member adapted to stand stably on the ground, said base member having an upper surface; a rotator mounted to the base member and adapted for rotation about a substantially vertical axis; a target mounted to said rotator for rotation about said axis in a substantially horizontal orbit, said target being adapted to be struck by a golf putter from a home position; wherein the upper surface of the base member defines a recess which is configured to receive an insert, said insert having first and second opposite surfaces, said first surface being 15 made of or coated with a light-reflective material, and said insert being configured for installation in said recess in at least two different configurations, such that in one configuration, said first surface is visible to a user of the practicing aid, and in the other 20 configuration, the second surface is visible to a user, said recess being positioned on the upper surface of the base member such that when the insert is received therein in either of said configurations, the respective one of 25 the first or second surfaces is disposed generally beneath the home position of the target.

30 In this respect, the insert is reversible, thereby allowing a user to install the insert in the recess with either its first or second surface visible. By

positioning the recess, and therefore the insert, beneath the home position of the ball, a user can use the first surface of the insert to see at least a partial reflection of themselves, allowing them to assess whether 5 their stance is correct before striking the target, so that they have an opportunity to adjust their stance.

The light reflective material may be a metal amalgam which is applied to one surface of a transparent body, of a substantially uniform thickness, so as to provide a 10 mirror via the other surface of the transparent body. When a standard mirror of this type is used, the second surface of the insert is formed on, or provided on the reverse side of the amalgam, i.e. the side of the amalgam which does not reflect light through the transparent 15 body.

Preferably when said insert is installed in said recess in said one configuration, said first surface lies substantially flush with the upper surface of the said base member, and when said insert is installed in said 20 recess in said other configuration, said second surface lies substantially flush with the upper surface of the base member.

The recess may be adapted to allow manual removal of the insert from the stationary support. Conveniently, 25 this allows the insert to be removed from the support when its use is not required and also to assist a user in switching between opposite first and second surfaces of the insert.

Preferably said first and second surfaces of the 30 insert are substantially rectangular in shape.

Preferably said second surface is coated with or formed from a material that simulates the texture of grass on a putting green.

In this respect a user of the practicing aid has a choice whether to use the reflective side of the insert, in order to monitor their stance, or to use the textured side of the insert, so as to provide a more realistic 5 feel of putting on a putting green.

Brief Description of the Drawings

10 Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

FIG. 1 is a perspective view from above and to one side of a golf stroke training device in accordance with one embodiment of the present invention;

15 FIG. 2 is a plan view of the golf stroke training device of FIG 1;

FIG. 3 is a cross-sectional view of the golf stroke training device of the present invention along the line A-A of FIG. 2;

20 FIG. 4 is a cross-sectional view of the golf stroke training device of the present invention along the line B-B of FIG. 2;

FIG. 5 is a perspective, exploded view of the golf stroke training device of FIGS. 1 to 4;

25 FIG. 6 is an enlarged, perspective exploded view of a rotator unit which forms part of the golf stroke training device of FIGS. 1 to 5;

FIG. 7 is a perspective view of part of the rotator unit as shown in FIG. 6;

30 FIG. 8 is an enlarged, perspective view of a printed circuit board and associated electronic components of the golf stroke training device as shown in FIGS. 1 to 5;

FIG. 9 is a block diagram of the electronic components of the golf stroke training device in accordance with the present invention;

5 FIG. 10 is a schematic representation of an H-bridge drive circuit;

FIG. 11 is a plan view of a golf stroke training device in accordance with another embodiment of invention comprising a removable insert;

10 FIG. 12 is a plan view of the golf stroke training device of FIG. 11 in which the insert has been removed;

FIG. 13 is a perspective view from above and to one side of an insert which can be mounted in the golf stroke training device of FIGS. 11 and 12;

15 FIG. 14 is a plan view of a golf stroke training device in accordance with yet another embodiment of the invention comprising a removable golf putter guide;

FIG. 15 is a plan view of the golf stroke training device of FIG. 14 in which the golf putter guide has been removed;

20 FIG. 16 is a perspective view of a golf putter guide which is shown mounted to the golf stroke training device in FIG. 14;

FIG. 17 shows a different perspective view of the golf putter guide shown in FIG. 16; and

25 FIG. 18 is a cross-sectional view of the golf putter guide along the line X-X of FIG. 17.

Detailed Description of the Preferred Embodiments

30 FIGS. 1 to 5 show a golf stroke training device in accordance with a first embodiment of the present invention, indicated generally by reference numeral 1.

The device includes a generally flat base plate 2 having an upper surface 34 and an underside 35. As seen in FIG.

2, the base plate has a substantially linear front edge 14, an opposite arcuate rear edge 36 and two opposite side edges 37, 38. Preferably the base plate is formed from a durable thermoplastic synthetic resin material 5 which may be injection molded.

As best seen in FIGS. 3 and 4, supported at a central region of the base plate 2 is an upright spindle 3. The spindle, which is formed from metal, has, at a lower end thereof, a radially protruding collar portion 4 10 and a shoulder 23 at its uppermost end. The lowermost end of the spindle 3 is inserted into a hole provided in the base plate 2, such that the lowermost end of the collar portion rests on the upper surface 34 of the base plate 2. The lowermost end of the spindle 3 extends through the hole in the base plate, such that a small length of 15 spindle protrudes from the underside 35 of the base plate 2. The spindle 3 has a threaded bore which extends substantially along the entire length of the spindle 3. The spindle is removably secured to the base plate 2 by 20 means of bolt which is inserted into the lowermost end of the bore; the bolt having an enlarged head portion which engages the underside 35 of the base plate 2.

A rotator unit 5 is rotatably mounted on the spindle 3 and is supported by two stacked, annular roller 25 bearings units 6, which may be conventional ball bearings of the kind that are widely commercially available. The roller bearing units 6 are mounted on the spindle 3 with the lowermost of the bearings units being supported on the upper surface of the collar portion 4. The roller bearing units 6 define a substantially cylindrical outer 30 surface.

As shown in FIG. 3, the rotator unit 5, has a solid annular bottom wall 7 which faces the base plate 2.

Extending upwardly and orthogonally from the solid bottom wall is a generally cylindrical hub portion 8. The hub portion is shaped to fit tightly over the spindle 3 and the bearings 6, such that an inner surface of the hub portion 8 abuts substantially contiguously with the outer surface of the bearings units 6. On the outer surface of the hub portion 8, a shoulder 21 is formed adjacent to the upper end of the hub portion 8.

Substantially co-axial with the inner hub portion 8, 10 are two radially spaced, outer and inner optical encoder rings 9, 10 respectively which also are formed integrally with the rotator unit 5. Each optical encoder ring 9, 10 extends upwards and orthogonally to the plane of the bottom wall 7 of the rotator unit 5. The outer ring 9 15 defines the radial extremity of the rotator unit 5, and the inner ring 10 is positioned between the outer encoder ring 9 and the hub portion 8. Preferably the rotator unit 5 is formed as an integral unit by injection molding a thermoplastic synthetic resin material, although a unit 20 cast from metal could equally be incorporated into the device.

An annular gear member 22 is mounted on the shoulder 21 of the hub portion 8 as shown in FIGS. 3, 4 and 5. The annular gear member 22 is press-fitted onto the hub portion 8 so that it forms a tight fit. The outermost edge of the annular gear member 22 extends into a space between the hub portion 8 and the inner optical encoder ring 10, and has a series of teeth formed thereon for engaging a pinion gear 32 (described below). Preferably 25 the annular gear member 22 is molded from thermoplastic synthetic resin material, and thus may alternatively be 30 formed integrally with the rotator unit 5.

As shown in FIG 5, a modified standard golf ball 11 is attached to the rotator unit 5 via a substantially rigid cantilever arm 12 having inner and outer ends. The golf ball 11 has a blind bore of substantially constant 5 internal diameter that extends from the surface of the bore along a radial axis to a depth at least approximately equal to the radius of the ball 11. The internal diameter of the bore and the cross-section of the arm 12 are of dimensions that allow an interference 10 fit between the bore and the outer end of the arm. An adhesive may first be applied to the outer end of the arm or the surface defining the bore so that the assembly is held together more securely.

The diameter of the arm 12 is significantly smaller 15 than that of the ball 11, so that the arm 12 does not interfere with a strike to the ball made by a user of the device. Furthermore, it is preferred that the arm 12 be made of a fiber composite material. For example, a carbon fiber arm has good durability, whilst at the same time 20 being light in weight. If the arm was too heavy, this would be felt by a user of the device and would impart an unnatural feel to any stroke made. To minimize the weight of the arm 12, the arm may be hollow, as shown in FIG. 3.

The inner end of the arm 12, which is secured to the 25 rotator unit 5, is inserted through the outer and inner optical encoder rings 9, 10 of the unit via two aligned holes 24, 27 provided respectively in the encoder rings, as shown in FIG. 3. The hole 24 of the outer encoder ring is visible in FIG. 7. The arm 12 forms a tight fit in the 30 holes 24, 27.

Because the rotator unit 5 is rotatably mounted on the spindle, the attachment of the ball 11 and arm 12 thereto means that the ball can move in a circular orbit

about the spindle 3, the length of which orbit is defined by the distance between the ball 11 and the spindle 3. Generally, it is preferred that the ball 11 be mounted at a distance from the spindle 3 such that in one complete 5 orbit, the ball travels a total distance of at least 1.22m (4 feet). Preferably, the holes 24, 27 in the outer and inner rings 9, 10 are aligned so that, when the arm 12 is inserted, the lowermost point of the ball 11 is disposed as closely as possible to the upper surface of 10 the base plate 2, without the ball touching the base plate 2, or being impeded at any point in its orbit. Thus, the ball 11 may be positioned so that its lowermost point is disposed only about 1 to 5 mm above the base plate, although in some embodiments the distance may be 15 greater than this. An advantage of positioning the ball 11 as close as possible to the base plate 2 is that the closer the target is to the ground, the more accurately the device simulates the feel of putting a real golf ball on a putting green, thereby allowing a user to develop a 20 feel for a natural putting stroke.

As shown in FIGS. 1, 2 and 5, the base plate 2 has a series of optional putter alignment markings on its upper surface 34, juxtaposed the front edge of the base plate 2. The alignment markings comprise a series of straight 25 lines which are spaced along the length of the front edge 14, and extend substantially perpendicularly to said edge. Said markings may be either superimposed the upper surface of the base plate or molded thereon. The alignment markings 13 are of sufficient length so they 30 are visible to a user of the device for aligning the head of his putter therewith.

At a start position, as shown in FIG. 2, the ball 11 is suspended over the markings at a central point, such

that the markings are divided into two equal groups 18A, 18B, one group to either side of the ball 11. In order to practise his putting stroke, a right handed user will position the head of his putter to the right of the ball 11 and use the alignment markings to the right of the ball 18A for aligning his shot. Conversely, a left handed user will use the alignment markings to the left of the ball 18B for aligning his stroke. Typically, the alignment markings on either side of the ball 11 are spaced approximately 25.4mm (1 inch) apart. A user can refer to these markings not only to align the head of his putter so that it is square to the ball 11, but also for the purpose of lining up his back-swing and controlling his follow-through for imparting more or less power to the shot.

In addition to the putter alignment markings 13, the base plate 2 has a series of optional distance markers 15 which are visible on its upper surface. In the embodiment shown, the distance markers are formed by means of a plurality of formations 16, molded into the base plate 2 in a particular pattern. Each formation 16 forms an arcuate, half cylindrical recess in the upper surface of the base plate 2, and together the formations are arranged in a circle to define a regularly interrupted half-toroid. Adjacent formations 16 are separated from each other by a narrow strip 15 of flat-molded plastic, the narrow strips forming the distance markers. Each distance marker 15 is arranged in a radial fashion with respect to the spindle 3. As shown in FIGS. 3 and 4, the formations 16, protrude from the underside of the base plate 2, so that when the base plate 2 is placed on the ground, the formations 16 act as feet for supporting the base plate 2 slightly above the ground.

The circle of formations 16 and the orbit of the ball 11 are substantially mutually concentric, and preferably, the circle of formations 16 has a smaller radius than the orbit of the ball. This means that the 5 arm 12 moves directly over the formations 16 and distance markers 15. By ensuring that the formations 16 and distance markers are of substantially equal dimensions, and ensuring that, at its start position, the arm 12 rests over one of the distance markers 15, the orbit is 10 effectively divided into a number of smaller units. In the device shown in FIGS. 1, 2 and 5 the orbit is divided into twelve substantially equal sections. As the path is 1.22m (4 feet) in length, each time the arm 12 passes over one of the distance markers 15, an advancement of 15 the ball of 107mm (4 inches) has been made. In other embodiments, number markings and/or further radial lines may be provided on the upper surface of the base plate 34 to assist a user in determining how far the ball 11 has moved. Alternatively, the distance markers may consist of 20 a series of radial lines marked on the upper surface of the base plate 2.

As shown in FIG.1, an optional mirror 17 is attached to the upper surface of the base plate 2. The mirror is positioned adjacent the front edge 14 of the base plate 25 2, in-between the two groups 18A and 18B of putter alignment markings 13 and underneath the start position of the ball 11. The mirror is preferably sufficiently large that a user can use the mirror to ensure that his head is directly over the ball before he plays a stroke.

30 The mirror 17 may be permanently secured to the base plate 2.

Alternatively, as shown in FIGS. 11 and 12, in accordance with a second embodiment of the invention, the

mirror 117 may be removably received in a recess 85 provided on the upper surface of the base plate 2.

A front edge of the mirror-receiving recess 85A is positioned closely adjacent to the front edge 14 of the upper surface of the base plate 2. The recess extends away from said front edge 85A underneath the start position of the ball 11. The mirror 117 and recess 85 are typically, generally rectangular in shape and are proportioned to cover a large area of the upper surface of the base plate 2 in a region juxtaposed the front edge 14 of the base plate 2. The depth of the recess 85 matches the thickness of the mirror 117 so that once the mirror is placed into the recess, as shown in FIG. 11, the upper surface of the mirror 117 lies substantially 10 flush with the upper surface of the base plate 2. A depression of approximately finger-width size 86 is optionally provided along one of the edges of the recess, so that an edge of the mirror 117 can be accessed for manually removing the mirror from the recess 85. In 15 addition to, or as an alternative to the depression 86, a hole 87 may be provided at the bottom of the recess 85 for accessing the mirror 117 from the underside of the device so that the mirror can be pushed out of the recess.

The mirror 117 may be of a standard type comprising 25 a transparent body of substantially uniform thickness which is coated on one side with a metal amalgam, so as to provide a mirror via the opposite side, although any other "mirror" having a suitably reflective surface may 30 be used. Preferably the mirror is modified so that the one side is further coated with a material which simulates the texture and feel of a putting green. The modified mirror is of a rotationally symmetrical shape so

that it can be inserted and received in the recess 85 with either the "mirror side" or textured surface facing upwards.

In a third embodiment of the invention, a golf 5 putter guide 90 may be mounted juxtaposed the front edge 14 of the base plate 2, as shown in FIG. 14. The putter guide 90 may be molded from a thermoplastic synthetic resin material, and has a generally elongate shape, as shown in FIGS. 16 and 17. The golf putter guide 90 has a 10 flat upper surface 91 and a flat lower surface 92. The upper and lower surfaces 91, 92 of the golf putter guide are of the same dimensions, and are arranged parallel to each other. Extending between the upper and lower surfaces are two side surfaces 93, 94, each of which 15 provides a putter guide surface as described below.

Extending from the lower surface 92 of the golf putter guide 90 are two substantially identical cylindrical locating protrusions 95. The protrusions 95 are spaced from each other, and are positioned at opposite ends of 20 the golf putter guide 90. The base plate 2 has two correspondingly positioned sockets 96 adapted to receive the protrusions 95 for mounting the putter guide 90 securely to the base plate 2. The protrusions 95 and sockets 96 are dimensioned and arranged so that the 25 putter guide can be selectively mounted with either of the guide surfaces 93, 94 facing the ball 11. When the golf putter guide 90 is mounted as described, at least the guide surface 93, 94 facing the ball extends substantially vertically.

30 One of said putter guide surfaces 93 is arcuate, such that when viewed in horizontal cross-section, the guide surface 93 curves convexly; the curve may for example define the arc of an ellipse. The other guide

surface 94 is substantially flat. Typically, when viewed in vertical cross-section, as shown in FIG. 18, the guide surfaces 93, 94 are flat. However, it is envisaged that a putter guide 90, having guide surfaces 93, 94 with 5 respective non-flat profiles, when those surfaces are viewed in vertical cross-section, may also be used.

The golf putter guide 90 is positioned on the base plate 2 so that a user of the device can move the heel of his putter along, or align the heel of his putter with 10 the putter guide surface 93, 94 facing the ball 11, whilst playing a stroke to hit the ball 11.

For ease of manufacture, the golf putter guide 90 may be substantially hollow, and open at its lower end. In such an embodiment, the upper surface is defined by 15 the outer surface of an upper wall, and the putter guide surfaces 93 and 94 are defined by the outer surfaces of respective side walls which extend downwardly from the upper wall in the manner of a skirt. No lower surface 92 extends across the bottom of the golf putter guide 90; 20 instead the golf putter guide has a lower supporting surface on the lower edges of the walls forming the putter guide surfaces, and additionally the lower edges of any internal ribs which are molded into the interior of the golf putter guide 90. Locating protrusions may be 25 appropriately positioned on the lower edges of the walls forming the putter guide surfaces, or ribs. Alternatively, the locating protrusions may extend downwardly through the golf putter guide 90 from the interior, lower surface of the upper wall.

30 As shown in FIGS. 3 to 7 each of the outer and inner optical encoder rings 9, 10 comprises a series of annularly spaced apart formations, which in the illustrated embodiment take the form of upwardly

extending fingers 19, 20. The fingers 19 of the outer encoder ring 9 are of substantially equal dimensions and spacing. The fingers 20 of the inner encoder ring 10 are also of substantially equal dimensions and spacing. The 5 function of the fingers 19, 20 is to interrupt intermittently a beam of light - a separate beam of light being directed at each encoder ring (as described below) - as the rotator unit 5 rotates to produce a series of pulses of light which can be detected to generate a 10 pulsed signal. So that each ring 9, 10 produces a pulsed signal of substantially the same frequency for a given speed of rotation of the rotator unit 5, the width and spacing of the fingers 20 of the inner encoder ring 10 are proportionally smaller than the width and spacing of 15 the fingers 19 of the outer encoder ring 9, as shown most clearly in FIG. 7. Thus, as both rings 9, 10 rotate, the inner encoder ring 10 moves at a relatively slower circumferential speed than the outer encoder ring 9, and therefore the fingers 20 of the inner encoder ring 10 20 must be of a smaller width and spacing than the fingers 19 of outer encoder ring 9 in order to achieve substantially the same frequency of light pulses.

Unique to the inner encoder ring 10 is a home finger 25 which is of double the width of the other fingers 20 of the inner encoder ring 10. Furthermore, to one side of the home finger 25 is a home space 26 which is double the width of the spaces between all the other fingers 20 of the inner encoder ring. The reason for the difference in finger arrangement between the inner and outer encoder 30 rings relates to the respective functions of those rings. The fingers of the outer optical encoder ring 19 form part of an arrangement for detecting the speed of the ball 11 and for determining the direction of movement of

the ball 11, whilst the fingers of the inner encoder ring 10 form part of an arrangement for determining the direction of movement of the ball 11 and for returning the target 21 to the start position, as described in 5 further detail below.

As shown in FIGS. 3 and 4, a printed circuit board (PCB) 40 is supported on the shoulder 23 of the spindle 3 above said pinion gear 22. The PCB 40 carries electronic components of the device as described in more detail 10 below. The PCB, which is generally rectangular in shape, has a hole 41 formed in its central region for mounting on the uppermost end of the spindle 3. The hole 41 is dimensioned to allow the PCB to rest on the shoulder of the spindle 23. To secure the PCB in place, a second bolt 15 (not shown) engages the uppermost end of the bore of the spindle 3 and has an enlarged head which engages the upper surface of the PCB. Preferably the PCB has a thickness of about 3.2mm, which gives the board added strength and longevity. As can be seen in FIGS. 3 and 4, 20 the PCB 40 is supported on the spindle 3 a small distance above the uppermost extremities of the hub portion 8 and the optical encoder rings 9, 10; thus the PCB 40 does not interfere with the free rotation of the rotator unit 5.

With reference to FIG. 6 mounted to the underside of 25 the PCB 40 are two generally U-shaped optical sensor assemblies 50, 51. Each optical sensor assembly has a generally first rectangular upper portion 52, 53 having a flat upper surface, and two parallel arms 56, 56' and 57, 57' which depend from said rectangular portion 52, 53. 30 The rectangular upper portions 52, 53 serve as points of attachment for attaching the sensor assemblies to the underside of the PCB 40. Preferably, each rectangular portion 52, 53 has two opposing ends, and, at each end, a

hole 54, 54', 55, 55' through which a rivet or the like may be inserted; into the PCB 40 for securing the optical sensor assembly to the underside of the PCB. The arms 56, 56' and 57, 57' carry a photo-detector and an opposing photo-emitter, which are aligned on inwardly facing surfaces of the arms. Accordingly, for each optical sensor assembly, when a beam of light is emitted by the photo-emitter, the light is directed at and is detected by the corresponding photo-detector. Each photo-detector is adapted to output a high voltage when it detects light emitted by the corresponding photo-emitter and a low voltage when it does not detect light emitted by the corresponding photo-emitter.

As shown in FIG. 8, the PCB 40 has two arcuate holes 42, 43 respectively, each of which follows an arc having its center on said spindle 3. Each of the arcuate holes is flanked by a series of smaller round holes 42', 43'. The smaller holes 42' and 43' are each paired with another radially spaced smaller hole 42', 43' positioned directly opposite on the other side of the respective arcuate hole 42, 43, such that each arcuate hole has a series of pairs of smaller holes which are circumferentially displaced from each other. The paired smaller holes 42', 43' facilitate the attachment of the optical sensor assemblies 50, 51 to the PCB 40 via rivets or the like inserted through the holes of the rectangular upper portions 52, 53 of the sensor assemblies 50, 51 and into the PCB 40. The series of pairs of holes 42', 43' allows for adjustment of the positioning of the optical sensor assemblies 50, 51. The arcuate holes 42, 43 allow access to the optical sensor assemblies 50, 51 for connecting them to the circuitry of the device and to a power supply.

An outer one of the optical sensor assemblies 50 is positioned on the underside of the PCB 40 such that its two arms 56, 56' lie on opposite sides of the outer optical encoder ring 9. The photo-detector and 5 photo-emitter of the outer optical sensor assembly 50 lie in a plane that is level with the fingers 19 of the outer ring 9. The other optical sensor assembly 51 is disposed radially inwardly with respect to the outer sensor assembly 50, owing to the relative positions of the 10 paired holes 42', 43' as described above, and is positioned such that its arms 57, 57' lie on opposite sides of the inner encoder ring 10. The photo-detector and photo-emitter of the inner sensor assembly 51 are positioned such that they lie in a plane that is level 15 with the fingers 20 of the inner encoder ring 10.

As the rotator unit 5 rotates, the optical beams produced by photo-emitters of the optical sensor assemblies 50, 51, which beams are directed towards their corresponding photo-detectors, are intermittently 20 interrupted by the fingers 19, 20 of the outer and inner optical encoder rings 9, 10 respectively, such that the photo-detectors of the outer and inner optical sensor assemblies 50, 51 respectively produces pulsed output outer and inner motion detection signals, each comprising 25 a series of motion detection cycles, each motion detection cycle comprising a first transition from a low output voltage to a high output voltage when the photo-detector detects the leading end of a space after a finger, a subsequent transition from high output voltage 30 to low output voltage when the photo-detector detects the leading edge of the next finger following the space, and then a further low to high output voltage transition when the next space is encountered. The pulsed motion

detection signals are used by the device for performing a number of functions, including determining the distance traveled by the ball, calculating the instantaneous speed of the ball, determining the direction in which the ball 5 has been hit and determining whether the ball is at the start position; these functions are described in further detail below. The inner and outer optical sensor assemblies 50, 51 are arranged such that for a single motion detection cycle the inner motion detection signal 10 of the inner sensor assembly 51, when the rotator unit 5 is rotated in one direction, is offset from the outer motion detection signal of the outer sensor assembly by about 90°. Conversely, when the rotator unit 5 is rotated in the opposite direction, the inner motion detection signal 15 of the inner sensor assembly 51 is offset from that of the outer sensor assembly 50 by about 270°. Such an out-of-phase arrangement of the inner and outer encoder rings 10, 9 and inner and outer sensor assemblies 51, 50 is referred to in the art as quadrature.

20 Quadrature is well known in the art and may be used in the present invention for determining the direction of rotation of the ball 11, as described below.

As shown in FIG. 3, an electric motor 30 is mounted to the upper surface of the PCB 40 and is secured to the 25 PCB by three bolts which engage in three respective threaded bores 33 provided in the motor casing. (Only two of the bolts are shown in FIG. 3). The bolts are inserted from the underside of the PCB 40 through three holes 44 (see FIG. 8) provided in the PCB 40, the spacing of which 30 corresponds to the three bores 33 provided in the motor 30 and have enlarged head portions to engage the underside of the PCB 40. The motor 30 is mounted over a further hole 45 in the PCB 40 through which a depending

drive shaft 31, coupled to the motor 30, extends downwards into a cavity of the optical encoder unit 5 between the hub portion 8 and the inner ring 10. A pinion gear 32 as mentioned above is mounted on the free end of 5 the drive shaft 31, and is positioned such that its teeth engage with the teeth of said annular gear member 22. Thus, rotation of the drive shaft 31 and pinion gear 32 causes the rotator unit 5 to be rotated, thereby allowing rotation of the rotator unit 5 - and thus motion of the 10 ball 11 - to be controlled by the motor 30.

Operation of the motor 30 is controlled by electronic motor control means which are provided on said PCB 40. With reference to FIG. 9, said motor control means comprise an H-bridge motor drive circuit 82 which 15 allows the speed and direction of the motor 30 to be controlled. As shown in FIG. 10, the H-bridge motor drive circuit 82 comprises four switches Q1-Q4, and two feedback voltages Va and Vb. The motor 30 can be driven in one direction, in this case clockwise, by turning on 20 Q1 and Q3 such that M+ is connected to Vpos and M- is connected to Vneg. The longer that Q1 and Q3 are on, the greater the speed of the motor 30. Thus, by pulsing Q3 on and off, the speed of the motor can be controlled. Conversely, the motor can be driven in the opposite 25 direction by turning on Q2 and Q4, where M+ is connected to Vneg and M- is connected to Vpos. The speed of the motor is controlled by pulsing Q4 on and off. Accordingly, the drive shaft 31 of the motor 30 can be driven in either a clockwise or anti-clockwise direction 30 for speeding up or slowing down the ball 11, depending on the direction in which the ball has been hit. The pulsing of the switches on and off is a process generally referred to as Pulse Wave Modulation (PWM) and will be

recognised by those in the art as a energy efficient way of controlling motor speed.

Further supported on the PCB 40 is a liquid crystal display unit ('LCD') 60 for displaying information to a user. The LCD unit is substantially rectangular in shape and, as best seen in FIG. 8, has a flange 61 at its lowermost edge which flange extends about the entire unit 60 for securing the LCD unit 60 to the PCB 40. Said flange 61 has four holes 62 formed therein, one provided at each corner of the LCD unit, for attaching the LCD 60 to four upstanding hollow posts 63. Attachment is achieved by inserting a bolt (not shown) downwardly through each of the holes 62 and engaging it with a corresponding thread formed in a central cavity of a respective one of the posts 63. The posts 63, when secured to the LCD unit 60, depend from the lower surface of the LCD unit and the lowermost ends of the posts abut the PCB 40. The posts 63 are attached to the PCB by four more bolts which extend upwardly through four correspondingly positioned holes 46 provided in the PCB 40. Thus, the LCD unit 60 is supported over and is spaced from the PCB 40, such that other components can be mounted to the PCB 40 in a rectilinear recess defined between the LCD unit and the PCB.

With reference to FIGS. 3-5, the PCB 40 also supports a generally dome-shaped casing 64 which is shaped to cover and protect the rotator unit 5 and electronic components of the device 1. The casing comprises a cylindrical skirt 65 which extends downwards over the PCB 40, protecting the PCB and electronic components within the interior of the casing 64, but the skirt 65 does not extend so far that it interferes with the movement of the ball 11 about its circular path. Four

depending pillars 73 are molded on the inner surface of the casing 64. All four pillars are shown in transverse section in FIG. 2. Each of the four pillars 73 has a bore formed therein, which aligns with a respective one 5 of four corresponding holes 47 provided at each corner of the PCB 40. Accordingly, four bolts can be inserted from the underside of the PCB 40, through the holes 47, into the bores of the pillars 74 for securing the casing 64 to the PCB 40.

10 The casing 64 has a plurality of shaped apertures provided in its crown for allowing various components of the device to be accessed or clearly seen from above, as shown in FIG. 5. One aperture 66 is provided for allowing the LCD unit 60 to be read by a user. Two further 15 apertures 67 are provided for accessing push buttons 68 which enable a user to make selections related to operation of the device 1. The apertures 67 and consequently the push buttons 68 are positioned one to either side of the LCD unit 60. This enables at least two 20 player options to be displayed simultaneously at either end of the LCD unit 60. A user can then use the button 68 closest to his preferred option in order to make a selection. Each push-button 68 is preferably formed from rubber and has a stalk 69 via which each button is able 25 to contact a respective one of two pressure sensitive pads 75, 76 (see FIG. 9) which are provided on the upper surface of the PCB 40. Each time a particular button 68 is pushed, pressure is exerted on the corresponding underlying pressure sensitive pad 75, 76 and the pad 30 generates a corresponding command signal.

With reference to FIG. 3, a box-shaped recess 70 is also formed in the casing 64. The recess 70 forms a housing for a battery pack 71. In order to accommodate

the housing 70 within the device 1, a rectangular section of the PCB 40 is cut away at one of its edges, as shown in FIGS. 5 and 8. A removable access panel 72 is provided for closing the battery housing, which panel 72 can be
5 easily removed for inserting and removing cells.

The PCB 40 carries the electronic components necessary to process the signals received from the optical sensors 50, 51 and push buttons 68. Said electronic components comprise a microcontroller 80 including a microprocessor 84, and a suitable memory device 81 comprising pre-stored application software for operating the microcontroller in the manner described below. The microcontroller is "clocked" by a 12 MHz quartz crystal, which is internally divided into twelve
10 to provide an internal 1MHz time-base, thereby providing basis for measuring time to within $1\mu\text{s}$. The microcontroller 84 comprises an on-board timer-counter, typically a Programmable Counter Array (PCA), which includes a first 16 bit counter for counting from 0 to
15 65535. The first counter is free running and is adapted to run continuously without stopping during normal operation of the device. The application software provides a first software counter. As soon as the first counter reaches 65535 and returns back to 0, an interrupt
20 is generated which increments by 1 the first software counter. The PCA further comprises two further "outer" and "inner" 16 bit registers, which registers are associated with the outer and inner optical sensor assemblies 50, 51 respectively to act as a "capture"
25 register, the function of which is described below. Further associated with the microcontroller is a timer-counter which runs at about 2000Hz. This timer-counter is

used in measuring the speed of the ball as described below.

The functioning and interaction of the electronic components of the device are now described in detail, in 5 order further to describe the device in accordance with the present invention and its operation.

With reference to FIG. 9, the microcontroller 80 is central to the operation of the device. The microcontroller forms the central processing unit of the 10 device and is adapted to receive and process in accordance with said application software input signals from the various peripheral components of the device, including said command signals derived from selections made via the push buttons 68, and said motion detection 15 signals derived from the optical sensor assemblies 50, 51 as described above. The outer motion detection signal from the outer optical sensor assembly 50 is adapted to generate a high level interrupt on each transition from low voltage to high voltage. The microcontroller is 20 further configured 80 to co-ordinate responses to the input signals it receives and outputs control signals, including a motor drive signal for controlling said motor control means to control movement of the ball 11, and a display signal adapted to control said LCD unit 60 for 25 displaying information to a user. of how far the ball 11 has traveled. Generally this information is updated about twice a second so that a user can follow the progress of the ball whilst it is moving by referring both to the LCD unit and the ball 11 and its position in its circular 30 path.

In use the ball is arranged at said start position, ready to be struck by a user using a putter. With the ball 11 in the start position, the microcontroller 80

operates in accordance with the application software in a 'ready for putt' state. When the ball 11 is struck, the ball 11 is caused to rotate in its orbit as described above, with the direction of the strike - and 5 consequently the direction of rotation of the rotator unit 5 - depending on whether the user is right or left handed. When the first low to high output voltage transition is detected by the outer sensor assembly 50, i.e. when the outer sensor assembly first detects a space 10 - usually on the second finger transition - , an interrupt is generated which triggers the microcontroller to operate in a 'measuring velocity' state to measure the initial speed (V_{init}) of the ball 11. In this state, the instantaneous value (t_1) of the first 16 bit counter at 15 the moment when the first low to high voltage transition of the outer motion detection signal occurs is captured on the outer 16 bit register. The outer 16 bit register then captures the value (t_2) of the first counter when the next low to high voltage transition of the outer motion 20 detection signal occurs, i.e. once one space and finger have passed between the arms of the outer optical sensor assembly 50. The difference between the first and second counter values is calculated by the microcontroller. This provides a difference value (Δt) corresponding to the 25 time elapsed between the two consecutive low to high output voltage transitions:

$$\Delta t = t_2 - t_1$$

30 From the width (W) of each finger and space, this said difference value is used by the application software to calculate the initial speed of the ball 11.

$V_{init} = k_1 \cdot W / \Delta t$
where k_1 is a constant.

5 During rotation of the ball, the microcontroller maintains a software position variable which is reset when the ball is at the start position. Each time the microcontroller is interrupted by a low to high transition of the outer motion detection signal, the
10 microcontroller determines the direction of rotation of the ball 11, as described below, and increments the position variable by +1 or -1 depending on the direction of rotation to determine the instantaneous distance traveled by the ball.

15 Furthermore, the instantaneous value (t_n) of the first counter at each successive transition from low output voltage to high output voltage of the outer motion detection signal is recorded by the outer register, and the difference between the instantaneous value and the
20 previous value (t_{n-1}) is calculated to measure the instantaneous speed (V_t) of the ball 11:

$$V_t = k_1 \cdot W / (t_n - t_{n-1})$$

25 A second 16 bit counter is provided in order to improve resolution when the ball is moving slowly. As a way of doubling resolution, the microcontroller 80 could also be configured to record each high to low output voltage transition of the outer motion detection signal
30 in addition to each low to high output voltage transition.

 In order to determine the direction of rotation of the ball 11, the microcontroller 80 is configured to

5 compare the phase relationship as between the outer and inner motion detection signals by quadrature. If, as described above, the signals are about 90° out-of-phase then the microcontroller 80 determines that the ball 11 is moving in one direction, and if the signals are about 270° out-of-phase, then the microcontroller determines that the ball 11 is moving in the opposite direction.

10 Once the initial speed (V_{init}) has been measured, a notional total distance (D_{total}) to be traveled by the ball 11 is calculated by the microcontroller in accordance with the application software, taking into account any stimp value (S_n) which may have been selected by the user, using the equation:

15
$$D_{total} = V_{init}^2 / (k_2 \cdot S_n)$$

where $k_2 \cdot S_n$ is a deceleration factor dependent on the stimp value.

20 Alternatively, the application software may comprise a look-up table in the memory device 81 relating the notional total distance (D_{total}) to be traveled to the measured initial speed (V_{init}) of the ball for each of one or more user-selectable stimp values (S_n).

25 The microcontroller is configured then to calculate from the notional total distance to be traveled by the ball 11 (D_{total}) how quickly the ball 11 should decelerate from its measured initial speed so that it travels an actual total distance substantially equal to said notional total distance. This is achieved by generating a notional relationship between the instantaneous velocity (V_n) of the ball 11 and the elapsed time (t) after it has been struck, thus creating a velocity control algorithm:

$$V_n = f(t)$$

Alternatively, a look-up table of predetermined
5 velocity control algorithms could be stored in the memory
device 81 to provide a corresponding control algorithm
for each derived notional total distance.

The velocity control algorithm may be calculated so
as to simulate slopes and undulations on a putting green.
10 Thus a plot of V_n verses time will not comprise regular or
linear deceleration. For example, if the golf ball is to
encounter a downward slope a given distance after being
struck, then the velocity control algorithm would take
into account the effect that such a slope has on the
15 speed of the ball. The calculated velocity control
algorithm may thus cause the ball to accelerate at
certain distances, corresponding to the position of the
downward slopes on the selected putting green, instead of
causing the ball to continuously decelerate until it
20 reaches the desired notional distance.

Once the notional total distance and velocity
control algorithm have been obtained, the microcontroller
80 operates in a 'decelerating state', during which
control of the velocity of the ball 11 is achieved by
25 sampling the instantaneous velocity (V_t) of the ball 11
every 40 ms as measured by said timer-counter, which has
a cycle time of 500 μ s. When the timer-counter reaches
500, a second internal software counter is incremented by
1, which second software counter, when it reaches 80,
30 signals the elapse of 40 ms, causing a low priority
software interrupt to be generated, which in turn
triggers the microcontroller to compare the measured
instantaneous speed (V_t) of the ball 11 with the notional

speed (V_n) at that time according to the velocity control algorithm, and to derive an instantaneous velocity error value (ΔV):

5 $\Delta V = V_t - V_n$

Based on the instantaneous velocity error value (ΔV), the microcontroller calculates an appropriate motor control signal to control the motor control means if necessary to adjust the speed of the rotator unit 5 to cause the ball 11 to decelerate at a rate such that it will stop at about the notional total distance (D_{total}). The motor control signal is calculated from the instantaneous velocity error value in accordance with a proportional control algorithm that has desired speed as an input and motor drive as an output. If the actual speed (V_t) is higher than the desired speed (V_n), then using a table of desired speeds of the ball against percentage motor performance required to achieve those speeds - as derived by experiment and taking into account a margin of error-, the motor drive can be used to reduce the speed of the ball to the desired speed. Conversely, if the actual speed of the ball is lower than the desired speed, then the motor drive can be used to increase the actual speed of the ball. Such sampling and control of the ball's velocity occurs every 40 ms until the ball 11 stops. Typically the device may be configured such that when no further low to high voltage transitions of the outer motion detection signal are seen within a period of about two seconds, the microcontroller is programmed to determine that the ball has stopped moving and thus ceases any further control of the motor 30. Whilst the ball 11 is moving, the positional information obtained

may be used to calculate continually how far the ball has traveled. This real-time distance information is used to update the distance as displayed on the LCD unit 60.

In order to compensate for any difficulties that the 5 motor may have in driving the ball 11 at low speeds, the velocity control algorithm may be calculated so that deceleration of the ball is not controlled by said algorithm down to a speed of zero, but is instead controlled by the algorithm down to a near-zero speed. 10 The ball is then quickly brought to a halt after the near-zero speed is reached, and the distance that the ball will travel between the near-zero speed and halt is known. Calculation of the velocity control algorithm takes this "stopping distance" into account, thereby 15 allowing the ball 11 to be driven by the motor to the correct notional distance, without the motor having to decelerate the ball down to a speed of zero. Usually, the velocity control algorithm is calculated to control the ball to a speed of about 250 mm/s (10"/s).

20 Generally the calculated notional distance can be expressed as a number of fingers 19. For example, after a strike by a user the microcontroller may calculate from the initial velocity of the ball 11 a notional total distance of travel of the ball 11 of 1.22 m (4 feet) 25 which corresponds to a total of sixty fingers passing between the arms of the outer optical sensor 50. The microcontroller 80 compensates for the fact that generally three fingers 19 will have passed between the arms of the outer optical sensor assembly 50 before the 30 microcontroller is able to calculate the notional distance of travel of the ball 11. Thus, once the notional distance is determined, and from this, the number of fingers that the outer optical sensor assembly

50 must detect in order to reach that notional distance, a total of three fingers is subtracted from the total number of fingers, such that in the case of sixty fingers, the microcontroller decelerates the ball 11 so 5 that it stops after a detection of fifty seven fingers. In actual fact the microcontroller subtracts a further one finger from this total and controls the velocity of the ball so that it decelerates to its lowest controllable speed, i.e. 250 mm/s (10"/sec) at the fifty- 10 sixth finger. As soon as fifty six fingers have been detected by the microcontroller 80, the microcontroller causes the ball 11 to stop at the next finger, so the ball 11 travels the notional distance and effectively slows from a speed of 250 mm/s (10"/s) to 0 mm/s on the 15 last finger. This avoids any difficulties that may be associated with controlling the motor 30 to drive the ball 11 at speeds slower than 250 mm/s (10"/s).

After the ball 11 has been struck, it is likely that the ball will stop somewhere other than the start 20 position. Thus, before another strike is made, the ball 11 needs to be repositioned at the start. Although it is possible for the user to return the ball to the start position manually, the device described herein is adapted to return the ball 11 automatically to the start 25 position.

Firstly, an input selection by a user is required and this is achieved by pushing one of the push buttons 68 so that a user input command signal, in this case a home command signal, is transmitted to the 30 microcontroller 80. When such a signal is received by the microprocessor 80, the microprocessor immediately outputs a home restoration control signal which is transmitted to the H-bridge motor drive 82 for initiating a relatively

slow, constant-velocity rotation of the rotator unit 5. The microprocessor 80 then begins analyzing the outer and inner motion detection signals. As the rotator unit 5 rotates, the microcontroller detects a normal 90° out-of-phase relationship between the outer and inner motion detection signals. However, when the inner sensor assembly 51 detects said home finger 25, the phase relationship between the outer and inner signal changes from 90° out-of-phase to 270° out-of-phase owing to the double the width of the home finger as compared with all other fingers 20 on the inner encoder ring 10. The microcontroller 80 recognizes that this change of phase signals that the ball 11 has been returned home. The device is configured to stop when the next normal finger 20 on the inner encoder ring 10 is detected by the inner optical sensor assembly 51. This means that the home space also passes the inner optical assembly 51, thereby returning the phase relationship back to 90° out-of-phase.

The device is configured so that when the ball 11 is at the start position, the home finger 25 and home space 26 of the inner optical encoder ring 10 lie directly adjacent the arms of the second sensor assembly 51 being one standard-sized finger removed therefrom.

In use, the device 1 as shown in the accompanying drawings is placed by the user on the ground and is activated by operating an appropriate power-switch (not shown). The user then orientates himself adjacent the device, so that he is facing the device with the front edge 14 of the base plate 2 facing him. The LCD unit 60 indicates that the device is switched on and a number of play options are indicated to the user before he plays

his stroke, in accordance with the program. Such options include selecting a stimp value of the green and also resetting the device so that the ball 11 is returned home before the shot is played. Such selections can be made 5 using the buttons 68 positioned on top of the device (as described above). Once the appropriate selections have been made, the user stands facing the device, adopts an appropriate stance, aligns his putter with the ball 11 at the start position and strikes the ball. The ball 11, 10 once struck, orbits the spindle 3 in either a clockwise or anti-clockwise direction, depending on whether the user employs a left handed or a right handed stroke. The device determines in which direction the ball 11 has been struck and calculates the initial velocity (V_{init}) of the 15 ball based on the information it receives from the optical sensor assemblies 50, 51, as described above. The harder the ball 11 is struck, the faster its initial speed of rotation and thus the further the ball 11 should travel. The device uses initial speed measurement, 20 together with a selected stimp value (S_n), to calculate a theoretical final resting distance of the ball. The theoretical final resting distance is then used to generate a profile of desired ball velocity against time. The microcontroller 80 regularly samples the velocity (V_t) 25 of the ball and compares it with the desired ball velocity. If the actual velocity of the ball is higher or lower than the desired ball velocity, a proportional control velocity algorithm is used to either slow down or speed up the motor 30 so that the ball is kept on target 30 for stopping at the theoretical final distance. The distance that the ball 11 has traveled can be discerned from the distance markings 15 which are present on the base plate 2 of the device, but in addition the device

also displays the distance that the ball has traveled via the LCD unit 60.

In addition to simulating different putting green stimp values, the device may also simulate greens having 5 varying contours and undulations. Information concerning the relief of various greens can be stored in the memory device 81 of the computer 84 so that in addition (upon a strike to the ball 11 causing the H-bridge motor drive 82 to control speed and distance of the ball for a 10 particular stimp value), the microcontroller 80 sends control signals to the H-bridge motor drive 82 to accelerate or decelerate the ball further, depending on whether the simulated green slopes downwards or upwards or undulates. Such acceleration/deceleration of the ball 15 can be seen by the user in real time and may be particularly effective for use in situations where the device is used in connection with a video-game or other video-display as described in greater detail below.

The device may include means for ensuring that the 20 base plate 2 is horizontal when placed on the ground. Such means may include a number of feet of adjustable length which are provided on the underside of the base plate, and one or more spirit levels mounted on top of the device which indicate whether or not the device is 25 flat.

The device may incorporate a metronome which can be employed by a user to practice and improve the timing of their back-swing and stroke. Preferably the metronome can be operated independently of the main device and so can 30 be switched on and off by the user as desired.

As an alternative to battery power, the device may incorporate an appropriate socket for connection to a main power supply.

The device in accordance with the present invention may be programmed to operate in a games mode in which the device is connected to external equipment 83. For this purpose, the device may comprise a communication port. To 5 facilitate communication of the device with other equipment means of transmitting and/or receiving data to and/or from the other equipment may be provided within the microcontroller 84; for example a universal asynchronous receiver transmitter (UART) may be 10 incorporated into the device, although it will be appreciated that any other suitable communication port can equally be substituted into the device. Alternatively, the device may incorporate a bluetooth™ 15 device for wireless communication with external equipment.

The external equipment may comprise a game card that carries information that can be accessed and processed by the microcontroller 80. Alternatively the device may be linked to a games console, personal computer or other 20 electronic game; for example, the device may be used in conjunction with an amusement arcade game. Such a configuration may allow, for example, a player to challenge a famous professional golfer by attempting a "famous putt" made previously by that player. A visual 25 representation of a putting green may be displayed to user via a video display, and the user may then have the opportunity to perform the same putt, with the user's putt being simulated on the video screen. To make such a game as realistic as possible, information regarding the 30 contours of the various greens on which famous putts were played, may be stored in memory and accessible by the microprocessor in order to ensure that the correct acceleration/deceleration of the target is applied.

The training device as hereinbefore described thus measures the initial velocity of a ball following a putt by a user and uses this velocity to calculate the notional distance that an unconstrained ball would have 5 moved on a real putting green having a particular stimp value. The device uses this information to drive the ball to the correct final distance by applying appropriate acceleration or deceleration to the ball in order to ensure that the ball decelerates at the correct rate. 10 This provides the user with visual feedback of how far and how quickly the ball has traveled. Because a user does not have to alter his stance greatly in order to reset the device and play a subsequent stroke, a user is able rapidly to acquire a feel for an effective putting 15 stroke that can be transferred to the actual game. Additionally, the device can be used in a number of games modes to provide a realistic aspect to a golfing game.